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AN EFFECT OF SiO_2 AND CARBON NANO TUBES ON MECHANICAL PROPERTIES OF LM-12 ALUMINIUM ALLOY HYBRID METAL MATRIX COMPOSITE

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ABSTRACT

The present research is aimed to develop hybrid metal matrix composite using aluminium alloy LM-12 reinforced with constant weight percentage (9%) of SiO2 and different weight percentage (wt %) carbon nano tubes. After casting different mechanical tests were conducted such as Tensile strength, Hardness and Microstructure analysis of Hybrid Metal Matrix Composite developed experimentally. The method of developing and producing new composite material using a sand mould is by stirring casting method then allowed to solidify. Tests such as tensile test, hardness and microstructure analysis are to be performed on different specimens within the casting. The composite materials so produced are tested for their mechanical properties according to ASTM standards.

KEYWORDS: Aluminium Alloy LM-12, Carbon Nano Tubes, Tensile Test, Hardness and Microstructure Analysis

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Original Article

INTRODUCTION

The importance of composite material in today's world is progressively increasing with the growing demand for materials with high strength, thermal stability, high stiffness and less weight. A combination of two or more materials makes significant difference in chemical and physical properties, which produce a material of different characteristics from the original individual materials. This is called composite materials.

A composite material generally has two constituents, a base metal (matrix) and a reinforcement, whose combination gives better properties compare to that of individual component properties. The matrix which is normally a form of resin, binds the reinforcement, hence controlling the physical shape and dimensions. It also protects the reinforcement from environmental effects and transfers the load applied on the composite to the reinforcement, which is the main load bearing element. The reinforcement imparts the necessary stiffness, strength and thermal stability to the composites. The combination of two materials in composites enables it to achieve combinations of properties not attainable with metals, ceramics, or polymers alone. In Automotive industry, Railways, Aircrafts, Marine application HMMCs are used.

LITERATURE REVIEW

Al alloys are used in different engineering applications due to its versatile nature like better joining, machining and process ability. Al is most preferable material for many engineering application due to its properties like environmental friendly nature, less cost and good strength to weight ratio [1]. From fast few decades by using

different combinations of materials and varied size, shape and volume of reinforced many composite materials are developed. The distribution matrix alloy must be uniform to obtain the supreme properties of the metal matrix composite (MMC). The optimized bonding is there between these substances [3].

Rao and Das [4]in stirring method the molten alloy with an impeller by integrating alumina particles, aluminium-alumina composites prepared. Prasad et al. [5] wear behaviour has been observed for material with particles of semi-solid alloys and ceramic particle(s) reinforced AMCs. Reinforcement of SiC, Al2O3, Tic, C, B4C, fly ash, TiB2, Al3Zr etc. has been added, either singly or in hybrid ways. Alpas and Zhang [6] proved The SiC reinforcement is very effective in suppressing the transition to severe wear regime. Wilson and Alpas[7] describes about naturally occurring mineral reinforced composite and it reduce the cost. The properties of cast prepared by stir casting were studied by Singh et al. [8] studied about microstructure of the aluminium alloy sillimanite particle composites and it showed good mechanical property.

Singh et al. [9] also studied abrasive wear behaviour of the cast aluminium alloy reinforced with 10 wt.% sillimanite. Das et al. [10] prepared MMC (Al+CuAl2+Zircon) using stir casting method. Observed significantly improved wear resistance, with the addition of zircon sand particles in Al- 4.5Cu alloy. Suresh et al. [11] developed zircon sand (ZiSiO4) and silicon carbide SiC reinforced hybrid AMCs using a stir casting technique and by mixing appropriate reinforcement (75% Zircon sand and 25% SiC) showed improvement in wear resistance.

EXPERIMENTAL DETAILS

Material Selection

The experiment was conducted on matrix material LM-12. Matrix material chemical composition is shown in Table 1. The reinforcement used is pure $SiO_2$and carbon nano tube (CNT). Liquid metallurgy method was used for preparing the HMMCs. The stir casting method is used for preparation.

Table 1: Chemical Composition

Copper	Titanium	Manganese	Iron	Zinc	Lead	Tin	Nickel	Magnesium	Aluminium
9.0-11.0	2.5	0.6	1.0	0.8	0.1	0.05	0.5	0.2-0.4	Remainder

Preparation of Composites

Preparation of composite materials using stir-casting method and in this method a stirrer is used continuously to mix the particles into metal alloy while melting and immediately pour into the sand mould then cooled and allow to solidify. The particles often tend to form an aggregation in this method, which can be only dissolved by actively stirring with high temperature.

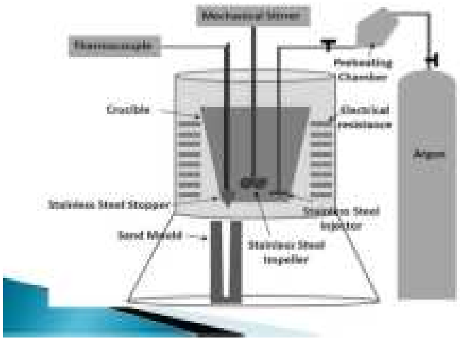
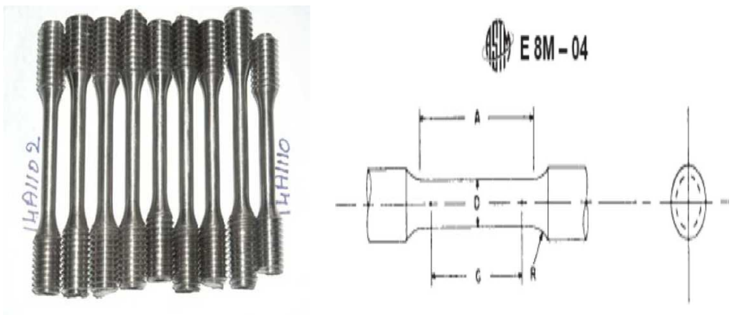


Figure 1: Stir Casting Setup

In this method graphite crucible is used to carry out the process in coal-fired furnace. Through continuous stirring of the molten metal-matrix we can prepare a homogenous blend of composites, mixture incontinently poured into the sand mould to get solidifies. As a fuel, coal is used for preparation. Calculated weight percentage reinforcement is added to the base metal using a mechanical stirrer to get homogenous mixture. Initially the LM-12 matrix material is heated to its melting temperature of about 700^0C. Reinforcing material SiO2 preheated to 500^0c and Carbon is preheated to 1000^0c. The blended appropriately mixture, then poured into the mould of size 150X120X25mm prepared using silica sand with 5% bentonite as the binder and 5% moisture and finally dried. To remove the internal porosity, nitrogen gases are passed to the mould since it is heavy, settles down in the cavity and drives other gases out of the mould.

Figure 2: Sand Mould



(a) **(b)**

Figure 3: (a) Photograph of Test Specimen (b) ASTM Drawing Specification

Composites Testing

Test on Tensile Strength

Figure 4: UTM-40T

Figure 5: Metallurgical Microscope

To find the tensile strength of the HMMCs, tensile testing specimens are prepared and tested. In figure 3 dimensions of the specimen prepared as per ASTM E8-M 04 rounds standards are shown. The specimens are prepared using traditional and CNC lathe machines. Figure 4 shows computerised UTM, using this machine we can determine tensile strength (UTS) of HMMCs samples.

Micro Structural Studies

Study the microstructure of the castings from selected areas of the samples using microscope. NIKON- Japan, ECLIPSE LV 150 optical metallurgical microscope is used for microstrucural studies. The specimens are undergone stages like a cut from desired location, ground, polished and etched as per ASTM standards as shown in figure 5 before the examination.

Micro Hardness Test

Figure 6: Vickers Hardness Tester

Hybrid metal matrix composites developed are tested for micro hardness. On all samples Vickers Hardness Test was conducted. Polished specimens used for microstructures analysis were used for hardness studies using micro hardness tester shown in figure 6. A time period of 10 seconds with a load of 10Kg was applied to the specimens.

RESULTS AND DISCUSSIONS

Tensile Strength Test

Figure 7: Tensile Test Braked Specimens

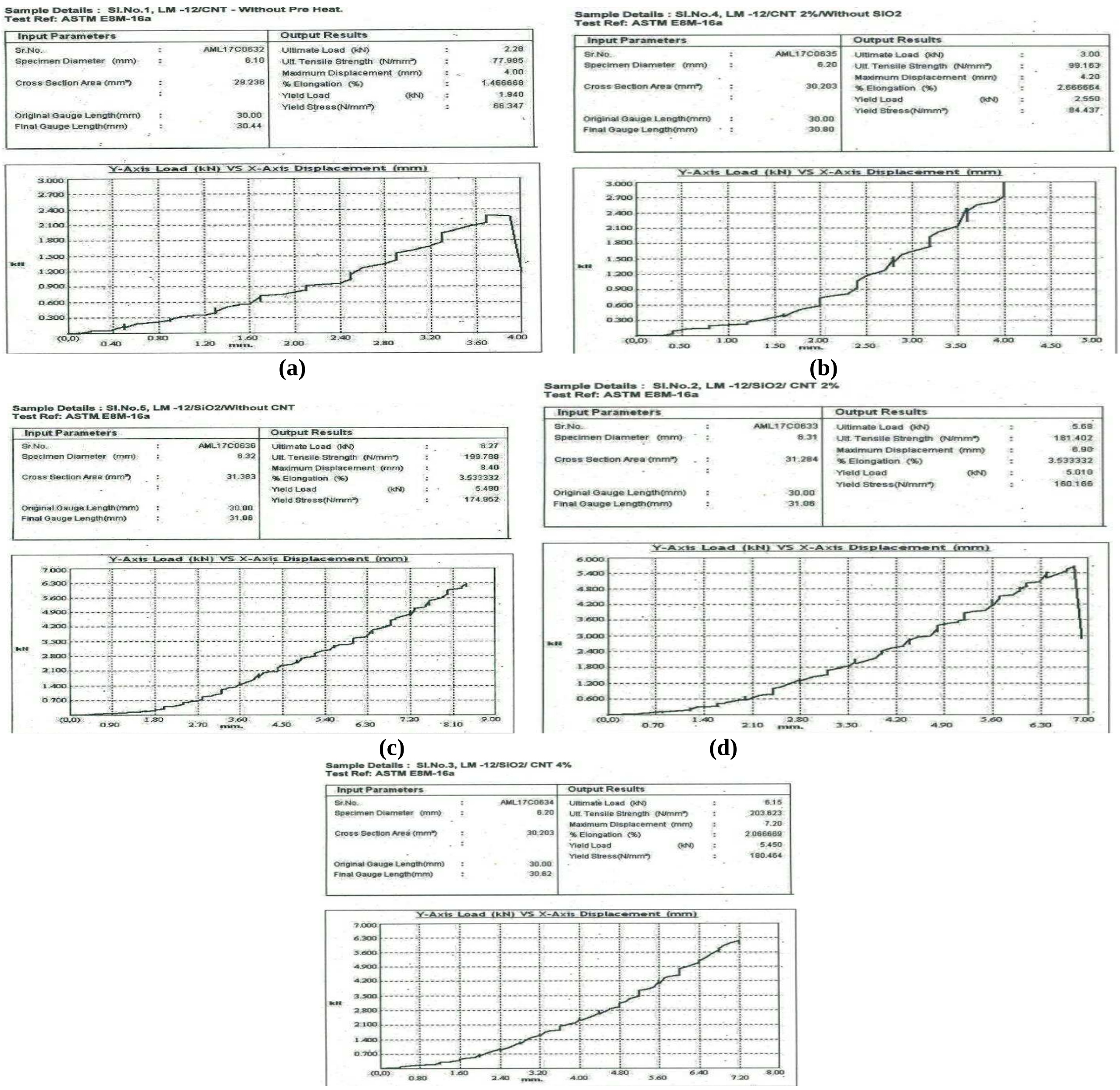
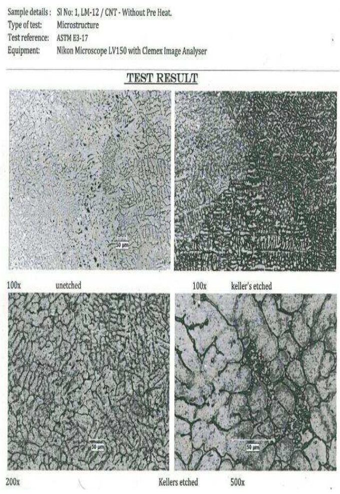


Figure 8: Tensile Strength Studies (a) LM-12/SiO_2/CNT without Preheat (b) LM-12/CNT without SiO_2 (c) LM-12/SiO2/without CNT (d) LM-12/SiO2/CNT 2% (e) LM-12/SiO2/CNT 4%

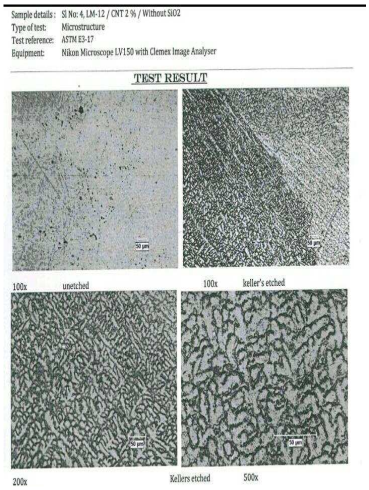
Discussion

From the above results, tensile strength is gradually increasing, once dispersion quantity is increased, since fused Sio2 and Carbon particulates is deep-seated in the LM-12 matrix. Mainly because of fine grain structure obtained in the hybrid metal matrix composites results higher amount of tensile strength observed.

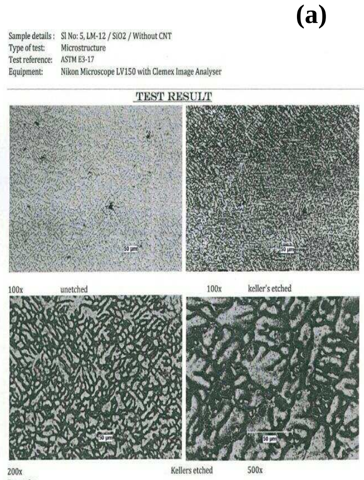
Microstructure Studies



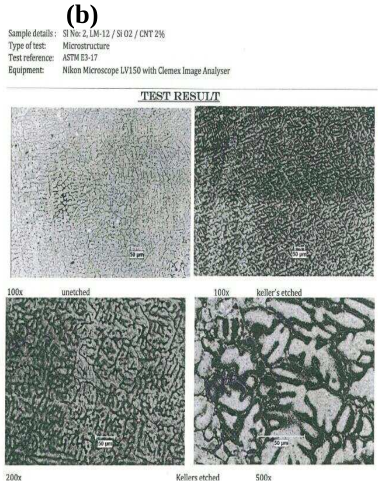
(a)



(b)



(c)



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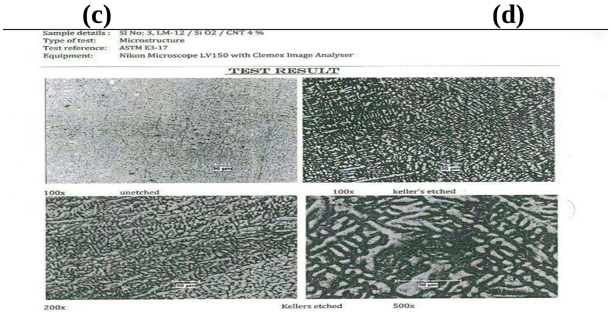

(e)

Figure 9: Microstrucural Studies (a) LM-12/SiO_2/CNT without Preheat (b) LM-12/CNT without SiO_2 (c) LM-12/SiO2/without CNT (d) LM-12/SiO2/CNT 2% (e) LM-12/SiO2/CNT 4%

Discussion

From microstructure studies, the constant weight% of SiO_2 and different weight % of the CNT, it is clear that

(fig9) particles dispersed uniformly throughout the matrix because of good density and proper method of stirring. Micro porosities have not observed in the pictures. From microstructural revisions, due to preheating of reinforcement and matrix the bonding is perfect and no mismatch between them is noticed.,

4.3 Micro Hardness Test

Table 2: Result of Micro Hardness Test

Designation of Composite	Hardness Value
LM-12/CNT-WITHOUT PREHEAT	122 HV1
LM-12/CNT-2%/WITHOUT SiO2	116 HV1
LM-12/SiO2/WITHOUT CNT	103 HV1
LM-12/SiO2/CNT-2%	110 HV1
LM-12/SiO2/CNT-4%	130HV1

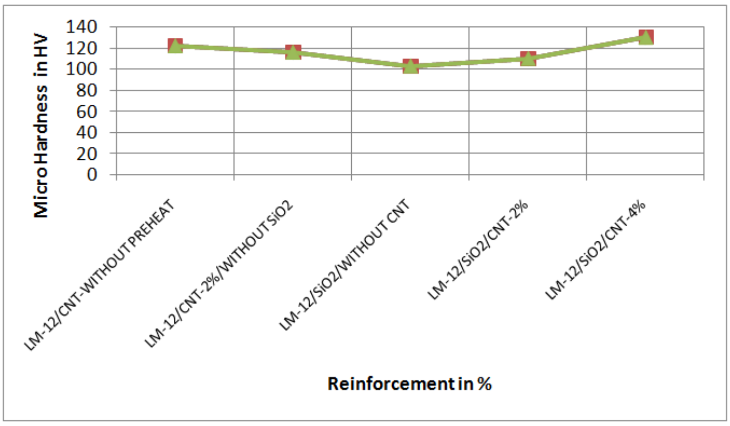

Figure 10: Hardness

Discussion

The resistance offered by a material to the surface indentation or abrasion is the measurement of hardness. From hardness test results we can consider that LM-12/SiO2/CNT-4% has high hardness value, as hardness value increases it is good for automotive industry, hence we can consider this composite designation has ductility, stiffness, elastic, toughness and viscosity because these are all dependent on hardness.

CONCLUSIONS

Because of low melting temperatures, LM-12 based hybrid metal matrix composite can be cast successfully using a stir casting method with the help of the furnace. The microstructure of the hybrid composites (LM-12+SiO_2+Carbon nano tube) is superior to that of metal matrix alloy scattering only with fusedSiO2 particles. Firm concourse was discovered with no cluster within the matrix and the particles. It is observed that LM-12 with SiO2 and CNT-4% content gives good strength and greater hardness.

The present work can be further expanded to study other behaviour of composites using other fibres and their further mechanical, thermal, tribological properties and the analysis results can be correspondingly be analysed.

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